2.0 MONITORING PROGRAM OVERVIEW

The primary goal of the monitoring program is to address specific critical project needs. Its primary objectives will be to:

- establish baseline water quantity and quality conditions in each of eleven identified secondary basins,
- collect sufficient data to assess the effectiveness of current management practices, identify primary pollutant sources within each of the secondary basins, and develop and rank actions to correct identified problems to the greatest extent possible, and
- collect sufficient data to employ the HSPF water quality model in predicting the performance of various proposed corrective activities within the Estero Bay Watershed, including calibration and verification

The monitoring program will support the planned water quality modeling effort by providing data to drive the model and establish targets for both the calibration and verification of the model. The key elements and associated possible applications of the monitoring program are as follows.

- The establishment of long-term routine monitoring at the critical inflow and outflow locations within each of the identified secondary watersheds.
- The design and development of specific short-term intensive studies necessary to:
  - discriminate local land use loading characteristics;
  - determine loading variability resulting from differing agricultural and urban irrigation practices; and
  - assess the actual effectiveness of existing and proposed management practices (BMPs).
- The development of short-term synoptic studies at major conveyances to:
  - to provide intermediate targets for watershed model calibration; and
  - to identify areas where unusual loadings are occurring in the watershed.

2.1. Monitoring Program Support for Modeling

Every modeling project requires extensive parameter estimation as well as extension and extrapolation of the available data. The proposed monitoring program is intended to collect those key data required to support the modeling effort. While some of the data to be collected will provide direct measures of time series inputs to the watershed and its conveyance system, those data required for the modeling efforts will consist primarily of characterization data to be used as targets for both model calibration and verification. As such, the primary use of these data will be to help refine estimates for the model parameters. As in any modeling approach, many options are available for developing modeling parameters and useful estimation techniques applicable to the Estero Bay Watershed are available in the literature. Parameters such as rate constants needed for many of the detailed modeling processes will generally be initially derived from the available literature with some adjustment to reflect local conditions guided by local field data collections. Thus, a number of the modeling parameters must typically be fine-tuned during the model calibration/verification process, which is the primary use of the monitoring data in support of the modeling efforts.

It is not practical to fully characterize everything that could be used by the HSPF model within the design of the monitoring program unless time and budget for field and laboratory efforts are unlimited. Even if that could be done, it is well known that field data and/or laboratory values obtained under controlled conditions do not always translate well to estimating actual observed field conditions. As a result, calibration adjustments to the model will still be necessary. With the exception of site-specific, detailed studies of water column-sediment interactions, no explicit in-field efforts to determine various specific parameter rates are initially proposed for the monitoring program.

As a general guideline, the greater the number of monitored locations and the frequency of data collection, the more closely the model can be made to replicate actual measured conditions. However, there are practical limits beyond which there is little that may be gained with regard to the development of appropriate models from additional monitoring data. This practical limit is in part a function of the assumptions and inherent limitations in the model algorithms. For example, a simulation which can reasonably replicate available weekly data may be better than a model which matches only monthly or quarterly recordings, while no amount of effort on the modeler's part may be able to cause the model to closely duplicate daily or hourly recordings. Similarly, it may prove to be very difficult for the simulation model to produce a highly accurate representation of constituent concentrations at various locations and times throughout the watershed while the same simulation could very closely reproduce estimated weekly, monthly, or annual loadings. A discussion of some modeling considerations and difficulties in this regard is presented later in this report.

An attempt has been made in developing the monitoring program to balance the desire to measure everything, in order to learn as much about the system as possible, with the practical considerations. That is, that reasonable estimates can be made from studies of the major watershed components and critical locations to support the formulation of effective solutions to the watershed's problems.

2.2. Long-Term Routine Monitoring

The goal of the long-term monitoring program is to provide a substantial continuing database to establish and document both the natural and anthropogenically induced variability and changes in water quantity and quality within the Estero Bay Watershed. Long-term monitoring is further needed to assess the impacts of watershed management practices with regard to defining and attaining practical water quantity and quality goals within the watershed. The utility of long-term monitoring is that the data collected over an extended period of time are representative of a wide range of weather conditions, and evolving conditions in the watershed. Overall trends in water quality can be determined from such long-term data collections since short-term fluctuations become readily apparent and can be taken into account.

A review and analysis of water quality data from the existing long-term monitoring program being conducted in the Estero Bay Watershed by Lee County indicates that these current efforts are providing adequate coverage for the majority of the watershed (Figure 2-1). However, the current Lee County program does not include any monitoring sites in the Cow Creek secondary basin, and only two collection locations east of I-75 for any of the other secondary basins. The existing Lee County sites, however, do provide very good coverage of the downstream reaches of most of the direct inputs into Estero Bay.

The primary suggestion for the routine long-term monitoring is for the addition of sampling sites at the points of discharge from each of the secondary basins in the Estero Bay Watershed, including in Collier and Hendry counties to assess conditions in the Corkscrew Swamp and Lake Trafford secondary basins. These sites should be located to best determine potential loadings from the intense agricultural areas to the north of Lake Trafford. Additional characterization water quality data for the Estero Bay Watershed will come from these locations and other areas throughout the watershed to be included in the proposed detailed short-term watershed studies and synoptic sampling studies recommended for the monitoring program. These additional short-term investigations will serve to provide sufficient auxiliary information to support the modeling effort and watershed assessment. The locations of these additional sampling sites are given in Figure 2-2.

The existing Lee County long-term monitoring locations are placed along the major conveyances within the Estero Bay Watershed, forming a reasonably complete network to characterize upstream inflows to the watershed from the majority of the estuary inflows. These existing long-term monitoring stations are shown in Figure 2-1. A critical element and major consideration for the long-term monitoring effort is the determination of how much of the contributing area is monitored and if it is sufficient to obtain a reliable characterization of loadings to the estuary from this source. Data gathered from these locations will serve as the primary water quality model calibration and verification sites. In addition, these data will be utilized as the primary assessment tools in measuring and determining future progress in attaining subsequently identified goals for the reduction of pollutant loadings from the Estero Bay Watershed.

In addition, there are a significant number of permitted point source dischargers located throughout the Estero Bay Watershed. It is suggested that actual discharge volumes should be determined and recorded, and characteristic water quality for each of these sources be measured. Routinely obtaining available flow and water quality monitoring data submitted by these dischargers can be prepared in time series form for use as inputs to the HSPF water quality model.

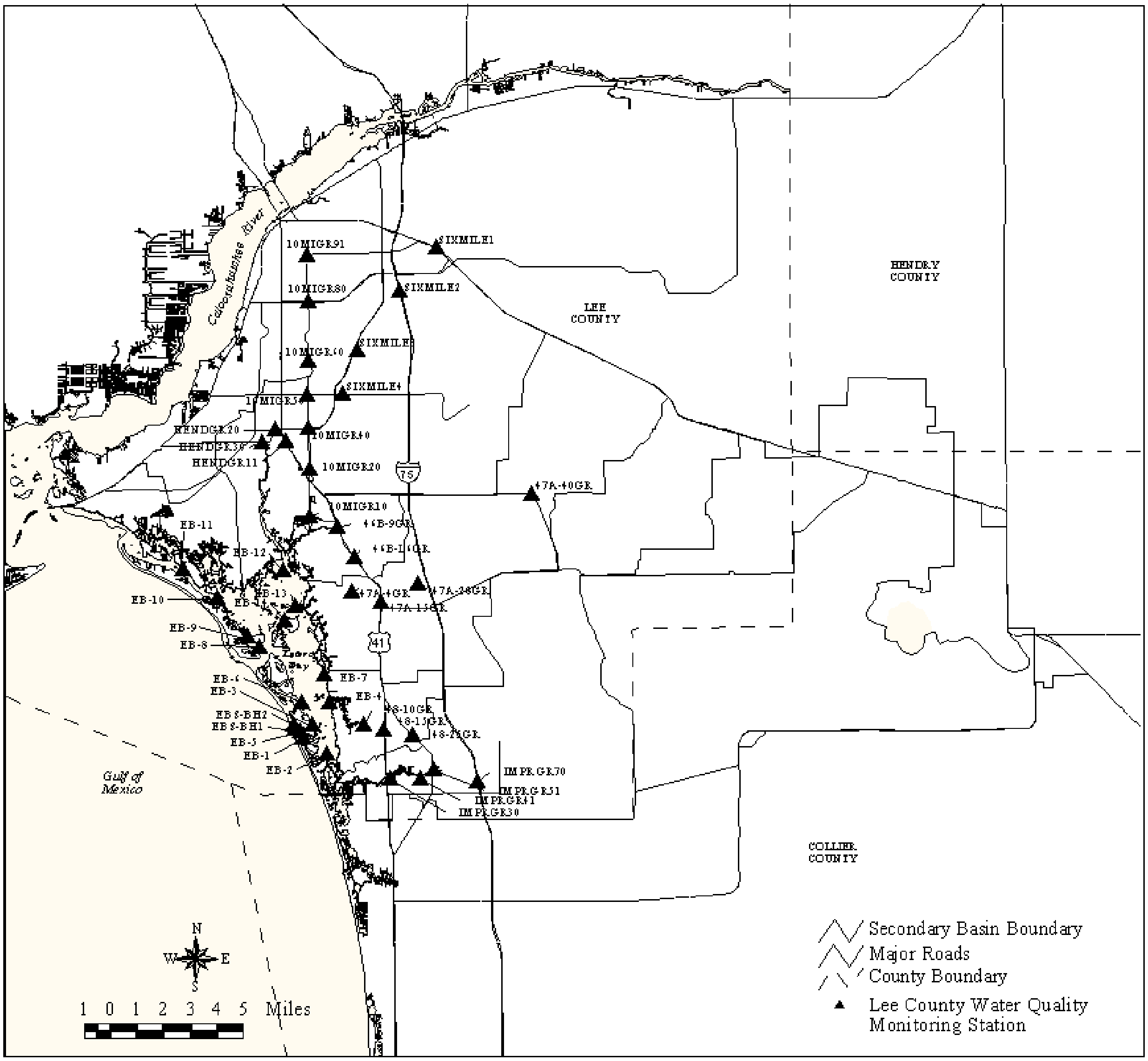

Figure 2-1. Location of Lee County water quality monitoring stations.

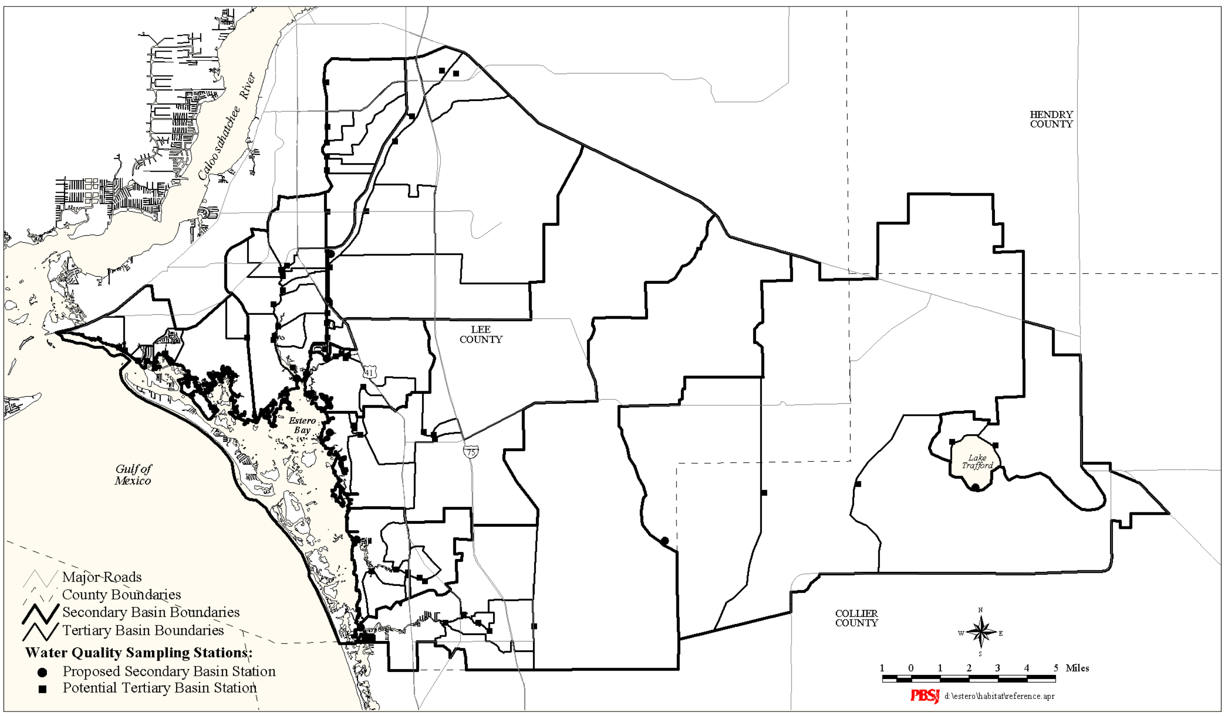

Figure 2-2. Locations of proposed additional routine long-term water quality watershed monitoring stations.

2.2.1. Sample Timing and Frequency

Data collected from long-term monitoring locations will be particularity useful for modeling purposes if it is generally collected at the same time (within reason) at all sample locations. Therefore, an effort should be made to modify (as necessary) the sampling schedules of the existing Lee County and any added long-term monitoring locations to provide to the greatest extent possible for synchronized in situ physical measurements and the collection of water chemistry samples. Synchronous sampling will allow the greatest use of the resulting data both in future watershed assessments, as well as the proposed modeling efforts. If data from various sampling locations within the watershed are several weeks out of synch, it will be particularly difficult for modelers to draw conclusions due to the uncertainties which will be necessary in trying to make extrapolations/interpolations from desynchronized data. Synchronization of the data by comparison will provide maximum calibration and verification targets to guide the modeler and provide a reliable measure of modeling success.

The long-term water quality monitoring programs being conducted by Lee County within Estero Bay and the surrounding watershed are currently being conducted on different schedules. At a minimum the following schedule changes should be made to the monitoring design for both the current collection sites, as well as any added in the future.

- **Watershed -** the current Lee County Estero Bay Watershed monitoring network includes 25 sampling sites located west of the north/south I-75 interstate corridor and 2 additional sites to its east (Figure 2-1). These sampling sites have been sampled continuously on a monthly basis since 1989. It is suggested that this program be augmented to include biweekly collections during the typical wet summer months (June-September). This schedule should be maintained as a minimum. Weekly monitoring during periods of higher flow could potentially provide significant improvement of model calibration and verification. A detailed evaluation of observed water quality fluctuation at specific sites should be made to determine if the monitoring frequency at selected locations should be increased to provide better assessments of loadings from specific secondary subbasin areas.

- **Estero Bay -** currently the Lee County sampling design includes the collection of data at 16 sampling sites located near the mouths of the major tributaries and in the bay. However, these data are only currently collected on a quarterly basis. An analysis of the data collected since 1989 under this sampling design indicates that the current sampling frequency is not sufficient to accurately assess the influences of seasonal freshwater inputs into the Estero Bay estuarine system. The Bay’s small size, shallow average depth, and multiple passes to the Gulf of Mexico combine to make its residence time extremely short when compared to the larger southwest Florida estuarine complexes to the north (Charlotte Harbor, Sarasota Bay, and Tampa

Bay). Therefore, at a minimum, the frequency at these bay sampling locations should be increased to monthly to provide an increased characterization of ambient seasonal conditions in these estuarine areas. However, even with such an added increase in sampling frequency it is unlikely, due to the bay's short residence time, that necessary assessments of the effects of freshwater inputs can accurately be determined. Such assessments of changes associated with freshwater inputs within areas of the bay can only be accomplished through the implementation of intensive short-term site-specific investigations.

Estimation of Diurnal/Tidal Variability

In addition to establishing defined long-term monitoring programs within the watershed and bay systems, additional efforts should be undertaken to specifically evaluate the magnitude of short-term diurnal/tidal variability within each of the measured water quality parameters. Studies in other southwest Florida estuarine and riverine systems have indicated significant, tidally independent diurnal variations in constituents such as dissolved oxygen and chlorophyll *a*. At a minimum, a series of sampling sites characteristic of: 1) watershed; 2) tidal tributary; and 3) Estero Bay conditions should be sampled approximately every four hours over a twenty-four hour period (7 times) each year during both typical dry-spring (April-May) and wet-summer (August-September) periods. The sampling frequency at tidally influenced sites should be adjusted to include, at a minimum, a complete characterization of conditions over an entire tidal cycle. Samples should be taken over a full range of incoming and outgoing conditions, including: 1) high slack; 2) mid outgoing; 3) low slack; and 4) mid incoming.

2.2.2. Parameters to Sample

The water quality parameters (Table 2-1) which are currently being monitored by Lee County at the long-term watershed and Estero Bay stations should be maintained.

Table 2-1. Lee County Water Quality Monitoring Parameters.

PARAMETER	WATERSHED STATIONS	ESTERO BAY STATIONS
Field		
Temperature	X	X
Dissolved Oxygen	X	X
pH	X	X
Salinity		X
Conductivity	X	

Table 2-1. Lee County Water Quality Monitoring Parameters.

PARAMETER	WATERSHED STATIONS	ESTERO BAY STATIONS
Laboratory		
Biological Oxygen Demand - 5 Day (BOD)	X	X
Nitrate Nitrogen	X	X
Nitrite Nitrogen	X	X
Ammonia Nitrogen	X	X
Total Kjeldahl Nitrogen (TKN)	X	X
Nitrate + Nitrite Nitrogen	X	X
Total Organic Nitrogen	X	X
Total Nitrogen	X	X
Ortho-Phosphorus	X	X
Total Phosphorus	X	X
Turbidity	X	
Total Suspended Solids	X	
Chlorides	X	
Chlorophyll *a*		X

Of these the only parameter not directly used by HSPF is specific conductance (salinity). The measured forms of both the macro-nutrients, nitrogen and phosphorus, are immediately applicable to the modeling efforts. Data of major ions and chlorophyll *a* are particularity useful for the more detailed simulation routines within the HSPF model. It is suggested that the monitoring efforts be expanded to include the following additional parameters:

- chlorophyll *a* (at all sampling locations),
- photosynthetically active radiation (extinction coefficient, k),
- specific conductance (at all sampling locations),
- color,
- dissolved ammonia nitrogen,
- dissolved nitrate + nitrite nitrogen, and
- dissolved silica.

While all of these water quality parameter measurements may not be directly utilized by the HSPF modeling effort, data regarding these additional constituents is often extremely useful when trying to develop a conceptual understanding of the interactions among the various influencing factors. The addition of these parameters will also make the data collected for Estero Bay and its watershed comparable with those data being collected in conjunction the Tampa Bay and Sarasota Bay National Estuary Programs, as well as the methods currently proposed for the Charlotte Harbor National Estuary Program.

2.2.3. Modeling Support Obtained from Long-Term Monitoring

The long-term routine monitoring locations provide data to characterize the major external nutrient and pollutant inputs and the major freshwater discharges from the watershed to the estuary . These data will serve as the primary model calibration and provide necessary verification targets. The following tables summarize the modeling data which should be obtained at a minimum from the long-term routine monitoring. Table 2-2 describes the use of data obtained from specific locations, while Table 2-3 describes the general use of data obtained from all locations. Detailed descriptions of the model inputs and parameters referred to in the tables are provided in Chapters 4 and 5 of this report.

It needs to be noted that an extensive effort will be required to document the actual quantities of freshwater input from each of the described secondary subbasins. The collection of these data will be complicated due to the lack of drop structures or weirs which would provide convenient points for such determinations. Also most tributaries flowing into Estero Bay are tidally influenced well inland due to the general gradual changes in elevations throughout the Estero Bay Watershed. It may be necessary to utilize alternatives to standard gauging procedures. One such method currently under evaluation by the U.S. Geological Survey are doppler flow recorders for use to determine net changes in flows in tidal waters.

Table 2-2. Modeling Data Obtained from Long-Term Monitoring.

LOCATIONS	DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY	RELATIVE IMPORTANCE OR INFLUENCE
Hendry Creek Secondary Basin						
HENDGR20	Flow	Output Calib. Time Series	RCHRES HYDR	OVOL	Continuous	High

Table 2-2. Modeling Data Obtained from Long-Term Monitoring.

LOCATIONS	DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY	RELATIVE IMPORTANCE OR INFLUENCE
HENDGR11 HENDGR30 HENDGR20	Suspended Solids	Output Calib. Time Series	RCHRES SEDTRN	SSED OSED	Biweekly or greater during high flows	High Medium Medium/Low
HENDGR11 HENDGR30 HENDGR20	Nutrients	Output Calib. Time Series	RCHRES GQUAL	DQAL SQAL many possible T.S. outputs	“	High Medium Medium/Low
HENDGR11 HENDGR30 HENDGR20	Nutrients	Output Calib. Time Series	RCHRES NUTRX (alternative section)	NUCF many possible T.S. outputs	“	High Medium Medium/Low
Ten-Mile Canal Secondary Basin						
10MIGR40	Flow	Output Calib. Time Series	RCHRES HYDR	OVOL	Continuous	High
10MIGR40 10MIGR50 10MIGR60 10MIGR20 10MIGR80 10MIGR91 10MIGR10	Suspended Solids	Output Calib. Time Series	RCHRES SEDTRN	SSED OSED	Biweekly or greater during high flows	High High Medium Medium Medium Medium Medium/Low
10MIGR40 10MIGR50 10MIGR60 10MIGR20 10MIGR80 10MIGR91 10MIGR10	Nutrients	Output Calib. Time Series	RCHRES GQUAL	DQAL SQAL many possible T.S. outputs	“	High High Medium Medium Medium Medium Medium/Low

Table 2-2. Modeling Data Obtained from Long-Term Monitoring.

LOCATIONS	DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY	RELATIVE IMPORTANCE OR INFLUENCE
10MIGR40 10MIGR50 10MIGR60 10MIGR20 10MIGR80 10MIGR91 10MIGR10	Nutrients	Output Calib. Time Series	RCHRES NUTRX (alternative section)	NUCF many possible T.S. outputs	"	High High Medium Medium Medium Medium Medium/Low
Six-Mile Cypress Slough Secondary Basin						
SIXMILE4	Flow	Output Calib. Time Series	RCHRES HYDR	OVOL	Continuous	High
SIXMILE4 SIXMILE3 SIXMILE2 SIXMILE1	Suspended Solids	Output Calib. Time Series	RCHRES SEDTRN	SSED OSED	Biweekly or greater during high flows	High Medium Medium/Low Low
SIXMILE4 SIXMILE3 SIXMILE2 SIXMILE1	Nutrients	Output Calib. Time Series	RCHRES GQUAL	DQAL SQAL many possible T.S. outputs	"	High Medium Medium/Low Low
SIXMILE4 SIXMILE3 SIXMILE2 SIXMILE1	Nutrients	Output Calib. Time Series	RCHRES NUTRX (alternative section)	NUCF many possible T.S. outputs	"	High Medium Medium/Low Low
Mullock Creek Secondary Basin						
46B-9GR	Flow	Output Calib. Time Series	RCHRES HYDR	OVOL	Continuous	High
46B-9GR 46B-L6GR	Suspended Solids	Output Calib. Time Series	RCHRES SEDTRN	SSED OSED	Biweekly or greater during high flows	High Medium

Table 2-2. Modeling Data Obtained from Long-Term Monitoring.

LOCATION S	DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY	RELATIVE IMPORTANCE OR INFLUENCE
46B-9GR 46B-L6GR	Nutrients	Output Calib. Time Series	RCHRES GQUAL	DQAL SQAL many possible T.S. outputs	“	High Medium
46B-9GR 46B-L6GR	Nutrients	Output Calib. Time Series	RCHRES NUTRX (alternative section)	NUCF many possible T.S. outputs	“	High Medium
Estero River Secondary Basin						
47A-15GR	Flow	Output Calib. Time Series	RCHRES HYDR	OVOL	Continuous	High
47A-15GR 47A-4GR 47A-28GR 47A-40GR	Suspended Solids	Output Calib. Time Series	RCHRES SEDTRN	SSED OSED	Biweekly or greater during high flows	High Medium Medium/Low Low
47A-15GR 47A-4GR 47A-28GR 47A-40GR	Nutrients	Output Calib. Time Series	RCHRES GQUAL	DQAL SQAL many possible T.S. outputs	“	High Medium Medium/Low Low
47A-15GR 47A-4GR 47A-28GR 47A-40GR	Nutrients	Output Calib. Time Series	RCHRES NUTRX (alternative section)	NUCF many possible T.S. outputs	“	High Medium Medium/Low Low
Imperial River Secondary Basin						
48-15GR	Flow	Output Calib. Time Series	RCHRES HYDR	OVOL	Continuous	High

Table 2-2. Modeling Data Obtained from Long-Term Monitoring.

LOCATIONS	DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY	RELATIVE IMPORTANCE OR INFLUENCE
48-15GR 48-25GR 48-10GR	Suspended Solids	Output Calib. Time Series	RCHRES SEDTRN	SSED OSED	Biweekly or greater during high flows	High Medium Medium/Low
48-15GR 48-25GR 48-10GR	Nutrients	Output Calib. Time Series	RCHRES GQUAL	DQAL SQAL many possible T.S. outputs	"	High Medium Medium/Low
48-15GR 48-25GR 48-10GR	Nutrients	Output Calib. Time Series	RCHRES NUTRX (alternative section)	NUCF many possible T.S. outputs	"	High Medium Medium/Low Low
Imperial River Secondary Basin						
IMPRGR30	Flow	Output Calib. Time Series	RCHRES HYDR	OVOL	Continuous	High
IMPRGR30 IMPRGR41 IMPRGR51 IMPRGR60	Suspended Solids	Output Calib. Time Series	RCHRES SEDTRN	SSED OSED	Biweekly or greater during high flows	High Medium Medium/Low Low
IMPRGR30 IMPRGR41 IMPRGR51 IMPRGR60	Nutrients	Output Calib. Time Series	RCHRES GQUAL	DQAL SQAL many possible T.S. outputs	"	High Medium Medium/Low Low
IMPRGR30 IMPRGR41 IMPRGR51 IMPRGR60	Nutrients	Output Calib. Time Series	RCHRES NUTRX (alternative section)	NUCF many possible T.S. outputs	"	High Medium Medium/Low Low

The relative importance of the preceding rankings is based on the expected overall contribution of the data collected at each sampling location in supporting the modeling efforts. Currently no set time limit is proposed for the duration of sampling at these long-term monitoring locations in support of the modeling efforts. That portion of the sampling only associated with calibration and verification of the models should be reduced or eliminated when sufficient data on each secondary watershed is completed. However, there will likely always be a need to monitor the major flows through the Estero Bay Watershed system at key downstream locations.

Table 2-3. Modeling Data Obtained from Long-Term Routine Monitoring

DATA TYPE	DATA FORM	HSPF MODULE / SECTION	HSPF NAME	SAMPLE FREQUENCY	RELATIVE IMPORTANCE OR INFLUENCE
Suspended Solids	Model Parameter Calibration	RCHRES SEDTRN	particle data, DWRHO shear stress, TAUCD TAUCS erodibility, M	Biweekly or greater when flowing	High
Nutrients	Model Parameter Calibration	RCHRES GQUAL	decay rates, FSTDEC	Biweekly or greater when flowing	High
Nutrients	Model Parameter Calibration	RCHRES RQUAL NUTRX	nitrification/denitrification rates, KTAM20 KTNO20 KNO320 volatilization of NH_3, EXPNVG	Biweekly or greater when flowing	High
Flow	Model Parameter Calibration	PERLND PWATER	LZSN, INFILT, KVARY, AGWRC UZSN, INTFW, IRC	Continuous	Med
Flow	Model Parameter Calibration	PERLND PWATER (updated)	SRRC, SREXP	Continuous	Med

The data collected at the long-term monitoring locations will be used to calibrate model parameters for reach processes directly. The constituent data will also be used, albeit more indirectly, to assist in the calibration of the upland contributing area model parameters. Gross discrepancies between monitored reach data and model predictions may require correction by adjustment of the upland area performance to increase or decrease loadings as required or to adjust the speciation of the nutrient outputs.

2.3. Short-Term Intensive Studies

Short-term studies proposed for the monitoring program are intended to address specific issues. The objectives of the short-term intensive studies are to:

- develop land use-specific loading estimates for priority categories of land use;
- perform field evaluation of the effectiveness of current stormwater and agricultural BMPs;
- determine differences loadings resulting from differences in agricultural land use practices;
- determine the potential contributions of sediment-water column nutrient cycling to water quality problems; and
- perform synoptic studies to determine concentration profiles along major conveyances and systematically identify areas responsible for excessive loadings.

The outlined program of studies can be considered as incremental efforts intended to improve the state of knowledge. The proposed studies are intended to fill data gaps or to supplement and confirm existing literature data.

2.3.1. Loading and Management Practices Studies

Loading and management practice studies involve instrumenting selected watershed subcatchments to determine in detail water quality characteristic of site-specific runoff under differing rainfalls, as well as investigate nutrient/sediment loading characteristics. The priority studies of this type proposed for the Estero Bay Watershed are:

- site-specific field evaluations of the effectiveness of current Best Management Practices (BMPs); and
- land use loading analyses to identify the actual runoff discharge rates and sediment and nutrient loadings produced by priority land use categories within characteristic areas of the watershed.

2.3.1.1 Land Use Loading Study Prioritization

The recommended land use loading studies were prioritized based on expected loadings and the relative contribution of each land use category to the overall watershed area. Extensive literature data exist to assign initial loadings to land use categories. Many land use categories can be grouped for the purpose of assigning modeling parameters due to reasonably similar characteristics. Available land use loading assignments based on literature data from previous studies and data compilations should be used during the initial development of the model. The model can then be fine-tuned from that point as site-specific field data become available. The recommended field studies are intended to provide monitoring of continuous hydrologic performance and to quantify storm event changes associated with observed variability in characteristic water quality parameters. The priority land uses, based on acres and percent of area in the watershed, used to assign monitoring priorities are listed in Table 2-4.

Table 2-4. Predominant developed and undeveloped land uses, by area, in the Estero Bay Watershed.

LAND USE CATEGORY	ACRES IN WATERSHED	PERCENT OF WATERSHED
Developed land uses		
Cropland and Pasture land	49,663	21%
Tree Crops	24,342	10%
Residential Medium Density	11,265	5%
Residential Low Density	7,108	3%
Disturbed Lands	5,596	2%
Undeveloped land uses		
Upland coniferous Forests	38,673	17%
Wetland Coniferous forests	35,726	15%
Wetland Hardwood forests	27,490	12%
Vegetated Non-forested Wetland	23,061	10%
Wetland and Forested Mixed	11,591	5%

The following sections provide some additional rationale for monitoring of the listed land use categories. Water/sediment interactions are discussed in a separate section due to different monitoring and study procedures.

2.3.1.2. Agricultural Areas

Agricultural land uses are an important consideration in some of the secondary basins, especially in areas of the Estero Bay Watershed east of I-75. Improved pasture, row crops, and citrus groves are the major agricultural land use categories and should receive the greatest emphasis to determine specific loading characteristics. Both row crops and citrus land uses can vary greatly in their potential nutrient loading characteristics depending on different irrigation practices. Other intensive agricultural activities such as dairy farms and cattle feed lots have often been found to generate high loadings. Such intensive agricultural operations in the watershed should be monitored if they do not have effective treatment systems and/or established Best Management Practices (BMPs). Preliminary candidate sites for agricultural loading monitoring, based on priority rankings by percent area in tertiary basins, are listed in Table 2-5.

Table 2-5. Priority tertiary basins for agricultural land uses, by percent area in tertiary basin, in the Estero Bay Watershed.

LAND USE CATEGORY	SECONDARY BASIN	TERTIARY BASIN	PERCENT OF TERTIARY BASIN	PRIORITY
Cropland and Pasture land	3	6	26%	1
	4	6	25%	2
	6	6	25%	3
	6	7	24%	4
Tree Crops	9	2	37%	1
	10	3	22%	2
	9	1	11%	3
	8	4	7%	4

2.3.1.3. Urban Areas

Urban land use categories have been well-studied in numerous other loading studies and the available literature should provide a solid basis for assigned initial land use-based loadings. Monitoring efforts conducted in the Estero Bay Watershed should be used to verify widely available literature values and provide additional detailed local information. Published literature values are available for characterizing residential, commercial, institutional, transportation, and industrial urban land uses. An increasing important urban land use in western portion of the Estero Bay Watershed is the proliferation of golf courses which are known for relatively high nutrient loading potentials.

Residential areas are included for proposed land use loading monitoring because they constitute a significant portion of the watershed area. Open areas under development are included due to the potential for significant suspended solids loadings in particular. Field observations have often noted that turbidity controls are not necessarily properly installed and maintained during development and other infrastructure construction projects. Observations in the Estero Bay Watershed identified many potential problem areas. Monitoring areas under development might include installations for shorter time periods to better match construction schedules. Preliminary candidate sites for urban loading monitoring, based on percent area in tertiary basins, are listed in the following table.

Table 2-6. Priority tertiary basins for urban land uses, by percent area in tertiary basin, in the Estero Bay Watershed.

LAND USE CATEGORY	SECONDARY BASIN	TERTIARY BASIN	PERCENT OF TERTIARY BASIN	RANK
Low-Density Residential	5	2	58%	1
	5	3	27%	2
	3	7	26%	3
	2	7	22%	4
Medium-Density Residential	5	4	65%	1
	8	5	61%	2
	6	4	61%	3
	3	1	47%	4
Disturbed Lands	4	7	24%	1
	3	3	87%	2
	3	5	23%	3
	2	10	8%	4

Although there are differences in loadings for the various urban residential density classes, the loadings are typically more similar to each other than to different land use classes. The identified areas under development listed in the table may now be developed, requiring field identification of additional candidate sites.

2.3.1.4. Natural Wetland and Forested Upland Areas

Contributions from natural areas are often a major component of the overall loadings in Florida systems due to the patterns of urban and agricultural development. These areas also represent the pre-development conditions which are used as the regulatory basis or as the base case for stipulating achievable pollutant load reductions. Monitoring of these land use classes is a fundamental effort required for the Estero Bay Watershed.

Wetland areas constitute a major portion of the watershed. Considering the proposed conceptual plans to enhance or restore wetland function in large portions of the watershed, observed loadings from wetland areas should be determined. Mature, healthy existing wetland systems should be selected for study to determine the ultimate loadings from proposed restored and enhanced wetlands.

Upland forested areas also constitute a significant portion of the watershed and deserve closer study to clearly define the loadings from these areas. It is important to properly characterize the larger land use areas so that incorrect assumptions do not distort or skew modeling predictions, or grossly overshadow other areas of concern in the watershed. Preliminary candidate sites for natural areas loading monitoring are listed in the following table.

Some of the sites are located within existing public and private conservation areas. This may be convenient for the safety of field equipment. Criteria for final site selection are identified below.

Table 2-7. Top four tertiary basins for undeveloped land uses, by percent area in tertiary basin, in the Estero Bay Watershed.

LAND USE CATEGORY	SECONDARY BASIN	TERTIARY BASIN	PERCENT OF TERTIARY BASIN	RANK
Upland Coniferous Forests	6	2	87%	1
	3	10	51%	2
	7	6	41%	3
	6	5	31%	4
Wetland Coniferous Forests	6	6	31%	1
	9	1	29%	2
	4	7	27%	3
	8	6	22%	4
Wetland Hardwood Forests	6	1	82%	1
	1	3	79%	2
	1	1	69%	3
	1	6	67%	4
Vegetated Non-Forested Wetland	2	3	39%	1
	2	4	20%	2
	10	2	17%	3
	1	1	16%	4

2.3.1.5 Field Evaluation of Best Management Practices

A valuable substudy for the loading analysis would differentiate between different management practices. A comparison study of a number of agricultural areas and/or urban areas which were otherwise similar but differed in the implementation or lack thereof of stormwater controls would provide an excellent baseline to monitor the effectiveness of current and proposed Best Management Practices (BMPs). Investigation of this type would provide the kinds of data needed to guide the predictive work to be performed as part of development of the water quality model, as well as provide necessary field testing and verification to encourage and/or force implementation of such future pollution controls throughout the watershed. By comparison, areas within the tertiary basins sharing similar land use and soils characteristics should be identified to provide for the selection of comparative monitoring sites, characterized by a lack of existing stormwater management facilities.

Another method of field testing current Best Management Practices (BMPs) would be to investigate an identified problem site which currently lacks proper storm ater controls. Such a site could be instrumented to collect data over both a wet and dry season to characterize loading characteristics under differing rainfall events. This site would then undergo continued monitoring to document changes in performance following implementation or construction of appropriate Best Management Practices. Such studies designed to field test and evaluate the performance of BMPs should logically and most efficiently use, whenever possible, some of the same sites instrumented for the land use loading studies.

Such field evaluations of the effectiveness of existing management practices should be a priority portion of the Estero Bay Watershed monitoring program since currently there is a general lack of detailed documentation and field data regarding the actual performance of the current stormwater controls. Currently many systems are installed under regulatory requirements which assume a certain effectiveness based on a somewhat limited basis of information. Very rarely are any data collected designed to test and document the actual effectiveness preceding and following the implementation of stormwater control programs.

Another potential study designed to evaluate proposed basin enhancements would be to instrument a degraded wetland for continued monitoring during the rehydration and restoration process. A paired study could be performed with one wetland undergoing restoration and one left in a degraded state. Comparison of data from these sites with data collected from existing healthy wetlands, as described above for the basic land use loading studies, should provide a fairly complete analysis of wetland issues in the Estero Bay Watershed.

2.3.1.6. Sampling Locations and Field Instrumentation

Potential subbasin areas identified for agricultural and development land use loading are listed in Tables 2-4 - 2-7. These potential monitoring site locations are based on the current available

District land use mapping (1995). Site access in terms of nearness to roads and some clustering of sampling locations to provide for easier, more efficient field efforts should be considered while preparing the final site selections. Further field efforts will be needed to assess the actual suitability of each site in detail and to make arrangements with the landowners for site access and the placement and protection of sampling equipment.

The ranking and selection of candidate watershed sites needs to address the following considerations:

- landowner/manager cooperation;
- well-defined drainage area (availability of detailed topographic data);
- single point of flow concentration;
- uniformity of land use; and
- site accessibility.

Additional considerations may include those specifically designed to evaluate irrigation and management practices:

Irrigation studies: how well local irrigation practice represents similar operations in the watershed.

Best Management Practices: studies of the effectiveness of:

- how representative proposed current BMP study areas are of future installation of similar BMP in other areas of the watershed; and
- capability to implement chosen management practice on selected subbasin watershed areas.

Each selected site will ideally contain primarily the land use of interest and should physically have a configuration of a well-defined watershed area leading to the concentration of a single point of flow having an unrestricted or metered area of discharge. It is critical to select a location where a reliable rating curve can be developed or to install a flume to facilitate flow recording. Generally, outfitting the site with an installed weir for study purposes is inappropriate due to the potential for ponding and sediment trapping unless this is a BMP under study.

Equipment needed for each instrumented subbasin or catchment area includes an on-site weather station to collect:

- precipitation and estimated evapotranspiration data;
- flow or stage recorder; and
- an automatic water sampler.

Due to the importance and influence of fluctuating surficial groundwater levels on surface runoff in the Estero Bay Watershed, shallow groundwater monitoring wells should be installed. Such an effort should be coordinated with existing efforts by Lee, Collier and Hendry counties, USGS, and FDEP.

The preliminary site selections should also consider the spatial distribution of the sites throughout the watershed. Each sampling location will require local monitoring of on-site precipitation and evapotranspiration data. Strategically locating these sites throughout the watershed will provide the added benefit for the collection of providing additional time series data. These data will be useful in evaluating the spatial variability of rainfall throughout the watershed and can subsequently be used to directly drive the final simulation model.

2.3.1.7. Land Use Loading Sampling Frequency and Duration

The primary goals of the various proposed land use loading, irrigation practice, and BMP evaluation studies are to collect necessary hydrologic and water quality data. Each of these subwatershed study sites should actively collect data for a minimum of one year (both wet and dry seasons), although in general it is recommended, in order to provide their maximum effectiveness, these programs should be initiated with the intention of collecting data for periods of three to five years to account for the expected between year variability in weather patterns. Average or normal weather patterns are the preferred basis for establishing long-term modeling predictions and the probability of collecting such characteristic data within any given year is extremely small. The District should evaluate the data collected at the end of each year and then decide if extending the period of study is warranted due to occurrence of drought or exceptionally wet conditions. It is possible that after only a year sufficient data will have been gathered to provide valid modeling results to adequately characterize the loading characteristic of the appropriate critical land use classifications. However, it is far more probable that additional monitoring of the same sites or alternate sites will be necessary.

Continuous data collection should be implemented for the hydrologic efforts. Groundwater levels in the monitoring wells should be obtained during weekly maintenance visits. Unfortunately, even with fully automated systems, field monitoring equipment requires frequent visits to ensure that equipment is functioning properly (i.e., good batteries, check calibrations, etc.) and to retrieve the data collected from non-telemetry equipment.

Water quality data collection is geared toward determining event mean concentrations (EMC) and total loadings from each representative event. The methodology of the EPA NPDES program is generally applicable. The goal is to sample representative storms that are typical for the area in terms of intensity, duration, and volume (mean annual event). Sampled events should be preceded by at least 72 hours of dry weather (to represent normal antecedent moisture conditions) and should be within 50% of the mean annual event for duration and volume.

EPA procedures call for a minimum of three events to be sampled to represent typical discharges but do not specify any seasonal considerations. The monitoring program should attempt to capture at least two event samples seasonally. If the results obtained during a given season at a given site do not compare well, additional sampling should be performed. Actual experience indicates that it may take a number of years to acquire such seasonal data. Water quality sampling equipment can be installed temporarily at each site until the requisite samples are collected.

The study of irrigation practices will also require close coordination with the landowner to obtain samples at times when excess irrigation water is discharged. Monitoring at these sites should attempt to collect data from both storm event and irrigation discharge events.

2.3.1.8. Sampling Methods and Parameters

The required sampling protocol is to collect a manual or automated flow-weighted composite with at least three aliquots taken during each hour of the discharge for the entire discharge or at least the first three hours of discharge. The entire composite is collected for a single analysis. One grab sample, preferably taken during the first 30 minutes, is also required.

Characteristic field measured constituents should include temperature, dissolved oxygen, specific conductance, and pH. Laboratory analysis should include total suspended solids, as well as the common organic and inorganic forms of the major macronutrients nitrogen and phosphorus. Five day biological oxygen demand (BOD-5) and chemical oxygen demand (COD) should also be determined if the detailed reach modeling approach requiring this data are to be used. Recommended field and laboratory methods and recommended QA/QC protocols are identified in a later section.

2.3.2. Water Column - Sediment Interaction

This monitoring category is discussed separately from the other land use loading categories because of the differences in monitoring and sampling procedures, and analytical methods.

A mechanism which should be examined is the potential for nutrient cycling between the water column and sediments in different waterbodies throughout the watershed. Many studies have shown that water quality within some waterbodies would not improve appreciably if all external loadings were removed due to the internal cycling with entrapped organic muck sediments. Generally these waterbodies function to trap sediments with no means for natural phenomena to flush them out. In such cases, sediment removal may be the only available method to improve water quality.

Sediment samples for this analysis could be collected at some of the stations addressed in the synoptic study. Sediment samples could also be collected in conjunction with the watershed land use loading analysis. For example, sediment characterization and potential for nutrient cycling within the irrigation or drainage ditches associated with citrus and improved pasture might prove extremely useful. Sediment samples could also be collected immediately downstream from the discharge point of the subwatersheds monitored for the land use loading studies and the BMP field evaluations.

2.3.3. Sediment Transport

Very little work, to date, has been done to characterize sediment transport in the major conveyances of the Estero Bay Watershed. As a result, there is only a limited amount of existing data on which to draw preliminary conclusions as to the importance of alterations of historic patterns.

2.3.3.1. Sampling Methods and Parameters

Sediment samples should be collected by appropriate sampling equipment depending on the nature of the sediment. The proposed investigations will generally be concerned with organic muck and silty sediments which can effectively be collected using a simple piston tube sampler. An analysis of particle/grain size should be done by a determination of grain size distribution. In addition, a chemical analysis is needed to determine the amounts and species of adsorbed nutrients. Recommended field and laboratory methods and recommended QA/QC protocols are identified later in this section.

2.3.4. Synoptic Study of Major Tributaries and Other Areas of Watershed

The objectives of the synoptic sampling studies are:

- to provide concentration profile data for the major tributaries; and
- to identify problematic areas of the watershed.

Development of concentration profiles along the major tributaries in the watershed at various times will provide valuable information for fine-tuning the modeling and for identifying areas where unusual loadings may be occurring. It is suggested that initially approximately 25-35 locations should be monitored among the major tributaries and in several urban and agricultural areas. The locations to be sampled would ideally match locations used in the modeling to separate various reaches in the system.

Data obtained from the locations on the major conveyances should be evaluated as they are generated and matched with incremental land use summaries produced from the project database. This will allow locations which are consistent with expected values to be eliminated from further sampling efforts and will allow additional sampling density to be focused on areas where problems are suspected. Data from the existing Lee County long-term monitoring program should be evaluated in detail and potentially some of the same sampling locations should be used to derive additional guidance and insight into the functioning of the watershed.

In order to gain the greatest utility from the data, sufficient flow or stage data should be collected to characterize or infer flow at each location. It is possible that a limited set of flow monitoring stations at greater intervals along the conveyances would be sufficient to allow reasonably accurate calculations of intermediate flows at intermediate locations. It is also possible that detailed locations for sampling can be coordinated with locations being flow-monitored for the hydrologic/hydraulic model upgrade.

2.3.4.1. Identification of Problem Areas

A portion of the sampling efforts should be geared toward a 'search and destroy' mission to identify and control pollutant discharges. This involves screening-level sampling during storm events and during dry periods. In addition, other sampling efforts should be conducted in urban areas to identify specific areas having potentially high loadings. The approach for this sampling effort is to seek out discharges that appear unusually polluted. If unusual problems are identified, follow-up investigations should be conducted to discover if this is a unique temporary problem or representative of a typical chronic condition. This effort would be conducted in part to identify areas which should potentially be fully instrumented for monitoring as described for the loading and management practices studies. Previous studies performed in the watershed should be closely reviewed to identify potentially useful sampling locations.

Additional efforts can be directed to dry season conditions. This involves seeking out areas where flows are occurring during periods of little or no rainfall. It is a bit more difficult to "dry screen" conveyances that routinely contain some water, but flows can be detected and the effort is worthwhile. The Florida Department of Transportation is held responsible for numerous stormwater discharge outfalls due to the location of the highway system and has found dry screening to be a very effective means of identifying illicit discharges and unpermitted drainage connections. These discharges nearly universally pose water quality problems requiring corrective action. FDOT's approach is generally to identify the problem source and place the burden of correction back on the upstream landowner or municipality (city, county, industry, etc.). Close cooperation and data sharing with FDOT would prove very beneficial to the District in addressing problems in the Estero Bay Watershed.

There is very little current information concerning existing levels of non-nutrient contaminants potentially moving from the watershed into the Estero Bay system. Such potential pollutants could include a wide variety of substances including: 1) heavy metals; 2) hydrocarbons (fuels and oils); 3) pesticides; and 4) herbicides. At a minimum, it is recommended that a short-term survey of sediment samples be collected from representative "suspect" areas based on exiting information. Such areas should include the downstream tidal zones of major drainage basin tributaries, as well as additional "background" areas. Volatile organic, semi-volatile organic, herbicide, pesticide and trace metal screens should be analyzed for each of these sampling utilizing the appropriate standard EPA protocols and methods. Based on the results of this initial study, both the locations and frequency of any additional further sampling efforts should be determined.

This portion of the monitoring program should maintain maximum flexibility to seek out problem areas and provide supplemental information to support and guide both the monitoring and the modeling efforts. For example, modeling predictions should be field verified as frequently as possible to assist in refining model parameter estimates.

2.3.4.2. Limited Verification of Land Use Loadings

To a limited extent, additional grab sampling can be performed to help verify that sites instrumented for the land use loading studies are producing representative results. For example, the citrus areas are generally configured in a very uniform way. Grab samples can be collected from other discharge sites nearby or adjacent to the instrumented sites for comparison. For this effort, the added grab sampling locations should be close enough to the instrumented sites that they are under the influence of the same rainfall which has been monitored.

2.3.4.3. Synoptic Study Sample Timing and Frequency

Sampling frequency should be controlled by periods of flow, occurring perhaps weekly during the rainy season and monthly otherwise. Sample timing should be closely coordinated with sampling performed at the long-term monitoring stations. This affords some economy in flow measurements, which can be inferred, but more importantly will connect the data collected to the long-term data. If the timing cannot be coordinated, then additional samples should be collected at the long-term monitoring stations during the synoptic sampling cycle to provide this coordination.

2.3.4.4. Sampling Methods and Parameters

Generally only grab samples need to be collected for analysis for the forms of the major macro-nutrients and TSS at locations along the major conveyances. Samples should be collected at a depth and location that is representative of the flow. Appropriate depths will need to be determined on a site-specific basis. Collection of the ‘surface film’ and floating detritus should be avoided to prevent producing unrealistically high analytical results. Recommended field and laboratory methods and recommended QA/QC protocols are identified later in this section.

2.3.5. Modeling Support Obtained from Short-Term Intensive Studies

The data collection activities for the short-term intensive studies fall into three categories:

- subbasin monitoring;
- water-sediment interaction; and
- synoptic sampling of tributaries and conveyances.

The final design of each of these activities should be configured to synergistically provide maximum support for specific aspects of the modeling effort.

2.3.5.1. Model Data from Subwatershed Monitoring

The proposed land use loading, and the Best Management Practice (BMPs) field evaluations are all designed to be of the subwatershed monitoring type. The instrumented subwatersheds are intended to generate continuous records of local weather in the form of precipitation and evaporation/transpiration data. The subwatershed monitoring efforts are intended to generate continuous records of runoff/flow discharge to provide sufficient calibration data to establish accurate estimates of the model parameters controlling runoff processes in the existing and the updated model. Water quality data are intended to be collected frequently enough (to include several representative storm events on a seasonal basis) to allow characterization of the loadings being generated from each specific area. The proposed sampling method provides for an event composite to characterize loadings and a single grab to confirm the analysis of the composite and possibly provide an indication of higher concentrations generated during the initial period of discharge during the storm event.

The utility of these data is somewhat subject to the success of the sampling activities. Storm event sampling is an extremely difficult task, even with modern automated equipment. Sampling teams and equipment have to be in the right place at the right time. In addition, there is never any guarantee that a properly captured event will also meet the desired criteria with regard to either intensity and/or duration. However, all data collected will be useful.

The following table identifies the modeling data to be obtained from the subwatershed studies. Detailed descriptions of the model inputs and parameters referred to in the table are provided in Chapters 4 and 5 of this volume.

Table 2-8. Model Data Obtained from Subbasin Studies

DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY AND DURATION	RELATIVE IMPORTANCE OR INFLUENCE
Precipitation	Input Time Series	PERLND PWATER	PREC	Continuous for 1 year (minimum)	High
Evaporation/ Transpiration	Input Time Series	PERLND PWATER	PETINP	Continuous for 1 year (minimum)	High
Flow	Output Calibration Time Series	PERLND PWATER	PERO SURO IFWO AGWO	Continuous for 1 year (minimum)	High

Table 2-8. Model Data Obtained from Subbasin Studies					
DATA TYPE	**DATA FORM**	**HSPF MODULE/ SECTION**	**HSPF NAME**	**SAMPLE FREQUENCY AND DURATION**	**RELATIVE IMPORTANCE OR INFLUENCE**
Suspended Solids	Output Calibration Time Series	PERLND SEDMNT	SOSED	Four Representative Events (2 per season)	High
Nutrients	Output Calibration Time Series	PERLND PQUAL	POQUAL many other T.S. for quantity or concentration	Four Representative Events (2 per season)	High
Nutrients	Output Calibration Time Series	PERLND NITR PHOS (alternative sections)	PONITR POPHOS many other T.S. by species by layer	Four Representative Events (2 per season)	High
Flow	Model Parameter Calibration	PERLND PWATER	LZSN INFILT KVARY AGWRC UZSN INTFW IRC	Continuous for 1 year (minimum)	High
Flow	Model Parameter Calibration	PERLND PWATER (updated)	SRRC SREXP	Continuous for 1 year (minimum)	High
Suspended Sediment	Model Parameter Calibration	PERLND SEDMNT	KRER JRER AFFIX KSER JSER KGER JGER	Four Representative Events (2 per season)	High

Table 2-8. Model Data Obtained from Subbasin Studies

DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY AND DURATION	RELATIVE IMPORTANCE OR INFLUENCE
Nutrients	Model Parameter Calibration	PERLND PQUAL	POTFW POTFS SQO ACQOP SQOLIM WSQOP IOQC AOQC	Four Representative Events (2 per season)	High
Nutrients	Model Parameter Calibration	PERLND NITR PHOS (alternative sections)	rate parameters	Four Representative Event (2 per season)	High

Such subwatershed monitoring will provide data for both calibration and verification of modeled upland runoff discharges. Model parameters are generally developed by initially assigning values based on available sources of information and making adjustments as needed to match the available calibration data. This is a flexible process which may involve adjusting some or all parameters related to a given hydrologic or water quality process. Often, reasonable assignments can be made to many parameters to bring model function close so that remaining calibration adjustments may be made with the least understood or documented parameters. An example used elsewhere in this report uses mineralization and demineralization rates for the nutrient species to complete the calibration because they are the least understood. Although there are unfortunately no 'rate parameter meters' available, the detailed chemical analysis of nutrient species provides the guidance to determine the rates.

All data obtained from these studies rank as 'High' in importance because of the way the data will be used and extended. The subwatershed studies will further provide the detailed characterizations of runoff loading needed for the major land use categories. These data will be widely extrapolated to apply to upland contributing areas throughout the watershed. The similar subwatershed studies performed for evaluation of Best Management Practices will demonstrate the differences resulting from those practices. Those differences will be reflected in changes in the calibrated model parameter values. The changes in the model parameter values will be used as guidelines to make similar changes to those parameters for other areas of the watershed. Thus, the influences of both older and newer management practices can be simulated throughout the watershed.

2.3.5.2. Model Data from Water Column-Sediment Studies

An analysis of the potential for nutrient cycling between sediments and the water column may be performed as part of the monitoring program. This information would primarily concern an in-stream mechanism that may increase dissolved nutrient loadings even in the event of significant decreases in external runoff loadings. The following table summarizes the modeling support obtained from the water column-sediment interaction study. Detailed descriptions of the model inputs and parameters referred to in the table are also provided in Chapters 4 and 5 of this volume.

Table 2-9. Model Data Obtained from Water Column-Sediment Interaction Study

DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY AND DURATION	RELATIVE IMPORTANCE OR INFLUENCE
Nutrients	Model Parameter Calibration	RCHRES GQUAL sediment mechanisms for decay and adsorption/ desorption	decay rates, ADDCPM, adsorption/ desorption rates	One-time study	Pending study results
Nutrients	Model Parameter Calibration	RCHRES RQUAL NUTRX (alternate sections)	benthal release rates, BRTAM, BRPO4 constant bed concentrations, BNH3, BPO4 partition coefficients, ADNHPM, ADPOPM initial adsorbed concentrations, SNH4, SPO4	One-time study	Pending study results

The study of water column/sediment interactions should consider which modeling approach will be used so that the rates needed for the specific final modeling selected are developed. Both the simpler (GQUAL) and the more detailed (NUTRX) modeling approaches require the same chemical analyses and the same equilibrium and leaching work. However, the two modeling methods differ somewhat in the rates which need to be developed from these basic chemical determinations.

Study of sediment transport will provide the needed modeling support listed in the following table. Detailed descriptions of the model inputs and parameters referred to in the table are provided in Sections 4 and 5 of this volume.

Table 2-10. **Modeling Data Obtained from Sediment Transport Study**.					
DATA TYPE	**DATA FORM**	**HSPF MODULE SECTION**	**HSPF NAME**	**SAMPLE FREQUENCY AND DURATION**	**RELATIVE IMPORTANCE OR INFLUENCE**
Suspended Solids	Model Parameter Calibration	RCHRES SEDTRN	particle data, D, W, RHO shear stress, TAUCD, TAUCS erodibility, M	As needed	Medium/Low
Suspended Sediment	Model Parameter Calibration	PERLND SEDMNT	KRER, JRER, AFFIX, KSER JSER, KGER, JGER	As needed	Medium/Low

The data obtained from the sediment transport study will be primarily useful for the characterization of the reach sediment transport routines in the model. To a lesser extent, because this is not a direct measure, the data will also be useful for the determination and confirmation of parameters for upland generated sediment discharges.

2.3.5.3. Model Data from Synoptic Sampling

One purpose of the synoptic sampling is to provide additional model calibration data at intermediate locations in the watershed. In particular, concentration profiles of the major conveyances will be prepared. These data are useful to assist in the model parameter development for in-stream processes and to assess incremental loadings to the reach from upland contributing areas. This will provide immediate confirmation that model predictions are on target at various locations throughout the watershed. The following table summarizes the modeling support obtained from the synoptic sampling. Detailed descriptions of the model inputs and parameters referred to in the table are provided in Chapters 4 and 5.

Table 2-11. **Model Data Obtained from Synoptic Sampling**.					
DATA TYPE	**DATA FORM**	**HSPF MODULE/ SECTION**	**HSPF NAME**	**SAMPLE FREQUENCY**	**RELATIVE IMPORTANCE OR INFLUENCE**
Suspended Solids	Model Parameter Calibration	RCHRES SEDTRN	particle data, D, W, RHO shear stress, TAUCD, TAUCS, erodibility, M	Weekly when flowing during rainy season, monthly otherwise	Medium

Table 2-11. Model Data Obtained from Synoptic Sampling.

DATA TYPE	DATA FORM	HSPF MODULE/ SECTION	HSPF NAME	SAMPLE FREQUENCY	RELATIVE IMPORTANCE OR INFLUENCE
Nutrients	Model Parameter Calibration	RCHRES GQUAL	decay rates, FSTDEC	Weekly when flowing during rainy season, monthly otherwise	Medium
Nutrients	Model Parameter Calibration	RCHRES RQUAL NUTRX	nitrification/ denitrification rates, KTAM20, KTNO20, KNO320, volatilization of NH3, EXPNVG	Weekly when flowing during rainy season, monthly otherwise	Medium
Flow	Model Parameter Calibration	PERLND PWATER	LZSN, INFILT, KVARY AGWRC, UZSN, INTFW, IRC	Weekly when flowing during rainy season, monthly otherwise	Medium/Low
Flow	Model Parameter Calibration	PERLND PWATER (updated)	SRRC, SREXP	Weekly when flowing during rainy season, monthly otherwise	Medium/Low
Suspended Sediment	Model Parameter Calibration	PERLND SEDMNT	KRER, JRER, AFFIX, KSER, JSER, KGER, JGER	Weekly when flowing during rainy season, monthly otherwise	Medium/Low
Nutrients	Model Parameter Calibration	PERLND PQUAL	POTFW, POTFS, SQO, ACQOP, SQOLIM, WSQOP, IOQC, AOQC	Weekly when flowing during rainy season, monthly otherwise	Medium/Low
Nutrients	Model Parameter Calibration	PERLND NITR PHOS (alternative sections)	rate parameters	Weekly when flowing during rainy season, monthly otherwise	Medium/Low

The data collected at the synoptic monitoring locations will be used to support the calibration of model parameters for reach processes. The constituent data will also be used to confirm the calibration of the model parameters for the upland contributing areas. Discrepancies between actual monitoring data and derived model predictions may require adjustments (increases or decreases) of the upland area loadings, or modifications to the speciation of the nutrient outputs. As such, a primary purpose of the synoptic sampling data is the identification of areas with the secondary and tertiary watershed subbasins where reality and model predictions are not in agreement. In addition, the data obtained from the synoptic sampling locations will serve several purposes beyond model support Discrepancies in the predicted and observed data may provide indications of the variability in the watershed and aid in the identification of particular problem areas.

2.4. Field and Laboratory Methods and QA/QC

The field and analytical methods for monitoring programs in the Estero Bay Watershed should be consistent with current FDEP Quality Assurance Standard Operating Procedures (SOPs) for field and laboratory activities. Field and analytical methods to be used for the continuation of the existing Lee County long-term monitoring program should be maintained to the extent they are consistent and/or acceptable to the FDEP Quality Assurance (QA) Section. Methods for any new monitoring programs should follow the guidance provided below to assure that data of the highest quality and acceptability are collected and reported.

Prior to the initiation of any new sampling programs, the Quality Assurance Section of the FDEP should be contacted to obtain the most recent requirements for field collection activities and laboratory operations as they may pertain to the monitoring program for Estero Bay Watershed. The current versions of FDEP procedures and Quality Assurance Plans that should be consulted for the appropriate field and laboratory methods are as follows:

- Standard Operating Procedures (SOPs) for Laboratory Operations and Sample Collection Activities (DER, 1992a); identified as DER - QA-001/92.

- Department of Environmental Regulation (DER) Manual for Preparing Quality Assurance Plans (DER, 1992b); identified as DER - QA-001/90.

Generally, it is recommended that all other field and laboratory methods follow approved FDEP Quality Assurance protocols. FDEP approved protocols are cited below for all field sampling and measurements as well as all analytical methods used in the laboratory.

2.4.1. FDEP Quality Assurance Protocols

At a minimum, the following chapters of DER - QA-001/92, or comparable chapters of the most recent version of SOPs provided by FDEP, are recommended, and referenced below, as guidance for field sampling activities, field and Laboratory QA/QC protocols, field and laboratory operations/analytical methods, and data management protocols. The laboratory performing analytical testing should have a current Comprehensive Quality Assurance Plan on file with FDEP.

2.4.1.1 Chapter Headings (from DER, 1992)

4.0 Sampling Procedures
- *4.1 Decontamination*
- *4.2 Aqueous Sampling Procedures*
- *4.3 Solid Matrix Sampling Procedures*
- *4.4 Sample Handling*

5.0 Sample Custody and Documentation
- *5.1 General Requirements for Custody and Documentation*
- *5.2 Preparation of Field Sampling Supplies and Equipment*
- *5.3 Custody and Documentation Requirements for Field Operations*
- *5.4 Sample custody, Tracking and Data Documentation for Laboratory Operations*
- *5.5 Electronic Data Documentation*

6.0 Analytical Procedures
7.0 Calibration Procedures and Frequency
8.0 Preventative Maintenance
9.0 Minimum Quality Control Requirements and Routines to Calculate and Assess Precision, Accuracy and Method Detection Limits
10.0 Data Reduction, Validation and Reporting
11.0 Corrective Action
12.0 Performance and System Audits
13.0 Quality Assurance Reports

2.4.2. Field Sampling Activities

Field sampling activities include equipment cleaning and maintenance, sample handling procedures, and chain-of-custody and documentation requirements. All field sampling activities should be conducted according to Chapters 4 and 5 (DER, 1992a).

2.4.2.1. Field and Laboratory QA/QC

Field Quality Assurance (QA) procedures are designed to assure the field samples and field measurement are taken in an accurate and consistent manner. In order to produce high quality data collected from the field, the sampling procedures in Chapters 4 and 5 (DER, 1992a) should be strictly adhered to in the monitoring program. In addition, any other applicable QA protocols in

Chapters 6, 8, and 10 through 13 (in DER, 1992a) should also be implemented to insure that the highest quality data is collected from the field.

Likewise, QA procedures applicable to laboratory analyses in Chapters 6, 7, 8, and 10 through 13 (in DER, 1992a) should also be followed by a qualified laboratory with an FDEP approved Comprehensive Quality Assurance Plan.

Quality Control (QC) procedures are designed to calculate and assess precision, accuracy, and method detection limits for measurements taken in both the field and laboratory. All measurements conducted in the field or laboratory should adhere to the QC requirement and routines documented in Chapter 9 (in DER, 1992a).

2.4.2.2. Field and Laboratory Operations/Analytical Methods

The list of approved methods in DER - QA-001/90 (DER, 1992b) should be used for measuring analytes measured from any of the recommended Estero Bay monitoring programs. Any deviations from the above cited methods should be approved through contact with the FDEP QA Section.

The following methods as listed in 40 CFR Part 136 Table IB have been adopted by FDEP in DER - QA-001/90, and thus, are recommended for measuring the analytes or parameters listed below. Parameters or parameter groups specific to each recommended monitoring program were previously identified in the description of each monitoring program. A few parameters listed below have not been previously identified with any of the monitoring programs but are included to provide method references to other commonly measured analytes. Although the analysis of salinity may not be critical to the monitoring program objectives, it is often easily measured in the field and provides good ancillary information as a conservative water mass property. It is recommended that salinity be measured from conductivity following Standard Method 25.2B (17th Ed.) as listed below. All other methods listed are “approved” FDEP methods.

Analyte / Parameter	**Method**
temperature	EPA (1983), 170.1
salinity	SM (17th Ed., 25.2B (from cond.)
specific conductance	EPA (1983), 120.1
dissolved oxygen	EPA (1983), 360.1
pH	EPA (1983), 150.1
color (PCU)	EPA (1983), 110.3 (spec)
turbidity (NT)	EPA (1983), 180.1
total suspended solids	EPA (1983), 160.2
chlorophyll-a (correct for phaeophytin)	SM 16th Ed., 1002G
	SM 17th Ed., 10200 H

total nitrogen	calculation (TKN + NO2-NO3-N)
total Kjeldahl nitrogen	SM 17th Ed., 4500-N org B or C
total ammonia nitrogen	EPA (1983), 350.1
dissolved ammonia nitrogen	EPA (1983), 350.1
total nitrite+nitrate nitrogen	EPA (1983), 353.2
dissolved nitrite+nitrate nitrogen	EPA (1983), 353.2
dissolved orthophosphate	EPA (1983), 365.1
total phosphorus	EPA (1983), 365.1 or 365.4
dissolved silica	USGS 102700-8 (autoanalyzer)
5-day BOD	EPA (1983), 405.1

2.4.3. Data Management Protocols

Data management protocols include the management, reduction, and validation of data collected from the field as well as from those data generated in the laboratory. Management of data should follow the requirements described in Chapter sections 5.4, 5.5, and Chapter 10 of DER (1992a).

2.5. Estimated Level of Effort

The components for each of the recommended monitoring programs are identified with respect to the estimated level of effort necessary to complete them on an annual basis. The number of samples, sampling frequency, the number of parameters measured for each sample, and total man-hours are estimated for each monitoring program. Following the summary of sites and sampling frequency and measurements for each program, annual (or study) man-hour estimates for sampling and basic data compilation are provided for each for the four monitoring programs.

2.5.1. Long-Term Monitoring

The primary goal of the proposed long-term sampling program will be to establish and document the natural ranges of both seasonal and between year variables in each of the key water quality constituents. The long-term monitoring program will also eventually provide the necessary base of data needed to determine if progressive changes are occurring in these water quality parameters. The monitoring program proposes ten long-term sampling stations be established, one at each of the discharge points from the ten secondary basins, excluding the Barrier Islands secondary basin. These locations should be sampled on a monthly basis for all of the water quality measurements previously listed.

The level of effort in terms of the number of sites sampled, sampling frequency, and parameters measured is summarized in Table 2-12.

Table 2-12. Summary of the Long Term Monitoring Program.			
Secondary Subbasins	**Frequency**	**Parameters**	**Approximate Number/Year**
Cow Creek - The proposed Secondary Basin sampling site is located in tertiary subbasin 6, which is the largest and receives much of the runoff from subbasin 7. Six additional sampling sites are also proposed to assess water quality associated with Tertiary Basins.	Monthly	In-Situ TSS Nutrients	84 84 84
Hendry Creek - The long-term Secondary Basin monitoring site should be located at the southern end of Hendry Creek such that it provides an integration of the influences of all ten of the Tertiary Basin. An additional eight sites are proposed to assess water quality coming from these Tertiary Basins.	Monthly	In-Situ TSS Nutrients	108 108 108
Ten-Mile Canal - The Secondary Basin site, located at the southern end of the Ten-Mile Canal would in fact integrate water quality coming from not only the Ten-Mile Canal subbasins, but also those within Six-Mile Cypress. A total twelve Tertiary Basin sites are also proposed.	Monthly	In-Situ TSS Nutrients	120 120 120
Six-Mile Cypress - The proposed Secondary Basin monitoring site would be upstream of the point where waters from this drainage basin join with those coming from the secondary Ten-Mile Canal subbasin. It is suggested that an additional five Tertiary Basin sites be sampled.	Monthly	In-Situ TSS Nutrients	72 72 72
Mullock Creek - As proposed, the Secondary Basin sampling site would actually be receiving runoff not only the Mullock Creek subbasin, but also that coming from both the Six-Mile Cypress and Ten-Mile Canal subbasins. An additional Tertiary Basin long-term sampling point is suggested.	Monthly	In-Situ TSS Nutrients	24 24 24
Estero River - The Secondary Basin monitoring location would include loadings coming from all of the areas with flows entering the Estero River. Six Tertiary Basin monitoring locations are also proposed.	Monthly	In-Situ TSS Nutrients	84 84 84
Spring Creek - The Secondary Basin site would be at the most downstream end of Spring Creek. An additional six Tertiary Basins monitoring sites are suggested.	Monthly	In-Situ TSS Nutrients	84 84 84
Imperial River - The Secondary Basin long-term monitoring location would be used to integrate water quality coming from the entire basin, while five Tertiary Basin sampling locations would be used to collect additional data.	Monthly	In-Situ TSS Nutrients	72 72 72

Table 2-12. Summary of the Long Term Monitoring Program.			
Secondary Subbasins	**Frequency**	**Parameters**	**Approximate Number/Year**
Corkscrew Swamp -A Secondary Basin and two Tertiary Basin sampling locations are proposed to assess long-term water quality conditions in this basin.	Monthly	In-Situ TSS Nutrients	36 36 36
Lake Trafford - The long-term monitoring sites for this basin include a Secondary Basin and two Tertiary Basin locations.	Monthly	In-Situ TSS Nutrients	36 36 36
TOTAL	Yearly	In-Situ TSS Nutrients	720 720 720

Parameters

In-Situ
(Parameters used directly by HSPF model)
- Temperature
- Dissolved Oxygen
- pH

(Parameters used indirectly for modeling)
- Specific Conductance
- Turbidity
- Photosynthetically Active Radiation
- Total Suspended Solids (TSS)

Nutrients
- Nitrite, Nitrate
- Ammonia
- Organic Nitrogen (or TKN)
- Ortho Phosphorus
- Total Phosphorus

2.5.2. Short-Term Monitoring

The level of effort in terms of the number of samples collected annually for each data type was estimated given the assumptions of the number of sites sampled for each category as shown in Table 2-13. The totals shown in the table represent the minimum number of samples to analyze assuming each event is sampled successfully and the desired size and duration of sampled storm events are met. A 25% sampling failure rate might be included to account for "false starts."

Table 2-13. Summary of the Short Term Monitoring Program.

Category	Number of Sites	Type of Data	Frequency	Approximate Number/Year
Landuse Loading	20	Weather & Flow In-Situ TSS Nutrients	Continuous 4 Events 4 Events - 2 Analyses 4 Events - 2 Analyses	Weekly Data 80 120 120
BMP Evaluation	4	Weather & Flow In-Situ TSS Nutrients	Continuous 4 Events 4 Events - 2 Analyses 4 Events - 2 Analyses	Weekly Data 16 32 32
Wetland Evaluation	2	Weather & Flow In-Situ TSS Nutrients	Continuous 4 Events 4 Events - 2 Analyses 4 Events - 2 Analyses	Weekly Data 8 16 16
TOTAL	26	Weather & Flow In-Situ TSS Nutrients	Continuous 4 Events 4 Events - 2 Analyses 4 Events - 2 Analyses	Weekly Data 104 168 168

Note: The parameters previously listed for the long-term monitoring program are also applicable to the synoptic monitoring program.

2.5.3. Synoptic Sampling

The approximate number of samples to analyze annually for the synoptic program is shown in Table 2-14. Estimates assume that 25 sites are sampled and that samples at each site are collected weekly 12 times (e.g., during the wet periods), and are collected at a monthly interval nine times (e.g., during the dry periods).

Table 2-14. Summary of the Synoptic Sampling Program.

Category	Number of Sites	Type of Data	Frequency	Approximate Number/Year
Synoptic Grab Samples	25	In-Situ TSS Nutrients	12 Weekly, 9 Monthly 12 Weekly, 9 Monthly 12 Weekly, 9 Monthly	525 525 525

Note: The parameters previously listed for the long-term monitoring program are also applicable to the synoptic monitoring program.

2.5.4. Water Column-Sediment Interaction Study

The number of sediment samples and the analytes to be measured for each sample was estimated assuming 30 sites are sampled in the Estero Bay Watershed. A summary of the these estimates is in Table 2-15.

Table 2-15. Summary of Sediment Monitoring Program.

Category	Number of Sites	Type of Data	Frequency	Approximate Number/Year
Sediment - Water Column Interaction	30	Grain-Size Analysis Organic Content Nutrient Elutriate	Once Each Once Each Once Each	30 30 30

Parameters

The recommended parameters to be measured from each sediment sample are listed below.

Grain-Size Analysis and Organic Content
Nutrient Elutriate - Nitrogen Species
Nutrient Elutriate - Phosphorus Species

2.5.5. Work Hour Estimates

The estimated work hours to collect the field measurements and samples, and to compile and tabulate the collected data are itemized below for each monitoring program. The estimated hours do not include laboratory analysis but do include in-situ measurements and equipment maintenance. The data compilation and tabulation estimates also do not include time required to do data analysis and interpretation, but only represent the basic minimal amount of effort necessary to present the collected data results in an organized fashion. The data compilation tasks include the efforts required to prepare the data in the basic time series form required by the modelers for use as model input and for comparison of actual and predicted results during model calibration and verification work. Other assumptions used to derive work hour estimates for each component are listed below.

Long-Term Monitoring

	Work hours/Year
Manually Sampled Sites 1.5 work hours/site X 60 sites X 12 times/year	1,444
Data Base Entry/Quality Assurance 16 hrs/month X 12 month/year	192
Data Compilation/Tabulation 12 work hours/month X 12 months/year	144
Long Term Monitoring - Total	1,776

Note: Does not include cost of chemistry analyses

Short-Term Monitoring

	Work hours/Year
Site Setup, 20 work hours per site X 26 sites	520
Sample Collection, 16 work hours per site per event 16 work hours X 26 sites X 4 events/year	1,664
Data Base Entry/Quality Assurance 16 hrs/month X 4 events/year	64
Sample Data Compilation/Tabulation 4 work hours per site per event X 26 sites x 4 events/year	416
Weather Data Collection (downloads), and Equipment Maintenance/Checks 24 work hours per week for 26 sites X 52 weeks/year	1,248
Short Term Monitoring - Total	3,912

Note: Does not include cost of chemistry analyses

Synoptic Study

	Work hours/Year
Sample Collection, 2 work hours per site X 25 sites 50 work hours X 21 events/year	1,050
Data Base Entry/Quality Assurance 16 hrs/event X 21 events/year	336
Data Compilation/Tabulation 20 work hours per event (all sites) X 21 events/year	420
Synoptic Study - Total	1,806

Note: Does not include cost of chemistry analyses

Water Column-Sediment Interaction Study

	Work hours/Year
Sample Collection, 80 work hours for all sites	80
Data Base Entry/Quality Assurance 32 for all sites	32
Data Compilation/Tabulation, 60 work hours for all sites	60
Sediment Study - Total	172

Note: Does not include cost of chemistry analyses